

28.**Diets for a Zoological Garden: Some Results During a Test Period of Five Years.¹****HERBERT L. RATCLIFFE**

Advances in animal nutrition have not been applied extensively to feeding problems of zoological gardens. Yet many of the difficulties inherent in maintaining health and vigor of wild animals in this environment probably could be solved in terms of information available either for related domesticated species or for man. Presumably adequate substitutes for natural foods would permit both the exhibition of more nearly normal animals and the maintenance of breeding colonies of many species. The economic aspects of either of these results are obvious.

During the first quarter of 1935 new diets were introduced at the Philadelphia Zoological Garden. For more than ten years before this time feeding practices had not changed materially. Therefore to aid in planning new formulae, records of mammals and birds that had been autopsied from 1924 to 1934 were reviewed for definite or presumptive evidences of malnutrition. Estimates of deficiencies, obtained by this review, were substantiated by comparing the values of foods that had been available to these wild specimens with those necessary to meet the known requirements of the nearest related species, whether man or domesticated animal.

Thus far, three mixed rations have largely replaced the various combinations of foods that had been used. One of these, with supplementary fruits and vegetables, is fed to the so-called omnivorous mammals and birds. A second, with mixed timothy and clover hay, provides for the herbivorous mammals. A third is a complete diet for the greater number of the Carnivora. This system includes neither fish-eating mammals and birds, nor specialized insectivorous animals.

The degree to which requirements have been met by these diets may be estimated at the present time only by changes in the causes of death, the death-rate, the birth-rate and the development of the offspring. More exact standards have been precluded to a large extent by conditions under which this study was conducted and by the types of animals involved.

Because of the great number of species represented in this collection, changes in the causes of death may be considered more completely only when more extensive material has been accumulated. But within the five-year test period just passed, changes in death rates, birth rates and in the development of young of several animal groups seem to justify the conclusion that these food mixtures have been reasonably successful. Increasing interest in certain wild animals as experimental subjects and requests for information on feeding them, suggest that some of these observations may interest others than those immediately concerned with the management of zoological gardens.

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At the present time, discussion must be limited to the reactions of certain species of animals and birds as members of relatively large taxonomic groups rather than as individuals. These groups, as such, are believed to have had approximately equal opportunity for breeding before and since the diets were changed. Exposure to morbid influences also has been equal, except of course, as modified by diet, or, in some instances, by reduction of the number of individuals within enclosures.

OMNIVOROUS ANIMALS.

The ration designed for this rather indefinite class of mammals and birds is made up of 1 part of ground, boiled horse-meat and 9 parts of the following mixture:

Rolled oats.....	20 per cent.
Whole wheat meal.....	20 " "
Soybean oil meal.....	20 " "
Peanut oil meal.....	10 " "
Yellow corn meal.....	10 " "
Buttermilk (dry).....	5 " "
*Brewer's yeast (dry).....	5 " "
Alfalfa leaf meal (dehyd.).....	5 " "
Oyster shell flour.....	2 " "
Iodized salt.....	2 " "
**Cod-liver oil concentrate.....	1 " "

These materials are mixed in bulk and used as needed. The ration usually is prepared the day before it is fed. First the ground meat and the dry materials are mixed thoroughly, then enough meat broth (water in which the meat is boiled) is added to form a stiff mash. This is pressed into shallow pans of convenient size and refrigerated overnight at 44 to 46 degrees F. after which it has hardened sufficiently to be cut easily into pieces appropriate to the size of the animals.

Allowing for natural variation in foodstuffs the approximate composition of this ration is:

Protein	25	per cent.
Fat	5	" "
Carbohydrate	45	" "
Calcium	1	" "
Phosphorus	0.5	" "
Iodine	0.017	" " (potassium iodide in "iodized salt.")

Energy value=3 calories per gram.

A variety of materials has been included in this ration with the intention of offering a palatable food of which animals would not tire quickly. The sources of protein are varied and the mineral and vitamin content have proved adequate for growth and reproduction except in instances that will be mentioned later. Obviously the formula may be varied and other substances added or substituted for those now in use.

Subhuman Primates. Thus far, animals of the following genera have been available for observation: *Gorilla*, *Pan*, *Pongo*, *Hylobates*, *Cercopithecus*, *Erythrocebus*, *Macaca*, *Theropithecus*, *Papio*, *Mandrillus*, *Saimiri*, *Cebus*, *Lagothrix*, *Ateles* and *Lemur*. Some of these generic groups contain relatively large numbers of species of which few have been represented in

* Brewer's Blended Dried Yeast. 1938 assay claims 30 international units of vitamin B₁ and 15 Sherman units of vitamin B₂ per gram.

** Assay claims: 3000 U.S.P. units of vitamin A and 400 A.O.A.C. "chick" units of vitamin D per gram.

the collection. With the exception of rhesus monkeys (*Macaca mulatta*), these animals are kept in heated quarters during cold weather, and have little exposure to sunlight except in summer.

Prior to 1935, more than half the total diet of these animals consisted of polished rice, boiled sweet potatoes and bananas. Green foods, citrus fruits, milk and eggs, were fed in significant quantities only to anthropoid apes (Corson-White, 1922).

Since 1935, about one-half the energy intake of subhuman primates of all ages has been supplied by the mixed ration, and, with exceptions to be noted, the remainder of their diet made up of uncooked fruits and vegetables: sweet potatoes, carrots, apples, bananas, citrus fruits and green vegetables. In addition to these food stuffs, anthropoid apes also receive from 1 to 4 liters of fresh whole milk each day. The two gorillas now in the collection also are fed about 200 grams of uncooked ground horse-meat each day, and an equal quantity of boiled horse liver 3 or 4 times each week. Pregnant and lactating females and immature animals of all types are given from 0.5 to 2 liters of a milk and egg mixture (1 egg per liter) and 5 to 20 cubic centimeters of a preparation containing some 800 units of vitamin A and 250 units of vitamin D per cubic centimeter.

This diet, mixed ration and fruits and vegetables, is estimated to supply at least 10 to 12 per cent of protein, 3 to 4 per cent. of fat and 30 to 40 per cent. of carbohydrate. Because of the relatively small amounts of calcium and phosphorus contained in vegetables and fruits the percentages of these materials in the mixed ration is reduced by at least half in the total diet.

The known daily energy needs of man and lower animals permitted the assumption that food requirements per unit of body weight would vary widely with the several species of subhuman primates in the collection. In consideration of size and spontaneous activity, allowances of 100 to 200 calories per kilogram of body weight per day did not seem excessive. In actual practice, however, amount of food taken may vary widely from day to day, and dominant members of a group must always be overfed so that others will be allowed adequate amounts of food. Also, frequent feedings² seem to be the most economical method of maintaining this type of animal, lessening waste and preventing overeating of any one food with subsequent loss of appetite for that or other substances. To accomplish this best, the keeper must return to the cages two or three times.

Table I is a summary of breeding and mortality records for each of the five years preceding and following the change of diet. "Total Stock" listed in the first column of the table includes all animals because records do not permit separation of potential breeding stock.

² Feeding schedule developed with the aid of Mr. M. I. Tomilin.

<i>Monkeys</i>	8:30 A.M.	Mixed ration (except on Sunday)
	11:30 A.M. to 12 M.	Green leafy vegetables
	2:30 P.M. to 3 P.M.	Sweet potatoes and carrots
	Offer water twice daily.	
From 4 to 16 ounces of mixed ration with 2 to 3 times these weights of vegetables will be required. Amounts are determined by size of the animals.		
<i>Chimpanzees and Orangs</i>		
	8:30 to 9:00 A.M.	Oranges (from October to May because of cost)
	9:00 to 9:30 A.M.	Whole milk
	11:00 to 11:30 A.M.	Green vegetables
	1:00 to 1:30 P.M.	Water
	1:30 to 2:00 P.M.	Sweet potatoes and carrots or tomatoes
	3:30 P.M.	Whole milk
	4:30 to 5:00 P.M.	Mixed ration except on Sundays when bananas are substituted
<i>Gorillas</i>	Feed according to the schedule for Orangs and Chimpanzees except that from 11:30 A.M. to 12 M. they receive raw ground horse-meat every day, and from 3:30 P.M. to 4 P.M., three or four times a week, each receives boiled horse liver.	

TABLE I.

Records of Births and Deaths for the Subhuman Primates at the Philadelphia Zoological Garden During Each of Five Years Before and Five Years After the Diet Was Changed.

Year	Stock		Acquisitions	Births	Deaths	Sales
	♂	♀				
1930	58	48	27	5	51	0
1931	48	39	21	2	19	0
1932	49	42	8	3	15	1
1933	48	38	9	3	11	0
1934	46	41	11	5	18	0
1935	45	40	30	6	17	15
1936	43	46	19	6	8	19
1937	34	53	13	5	7	4
1938	35	59	8	7	14	19
1939	28	48	9	12	5	0

From 1930 to 1935 the average annual birth rate was 1 for 11.6 females. This increased to 1 for 6.6 females after the diet was changed. Prior to 1935, breeding was limited to a few species of *Cercopithecus* monkeys, mainly *Macaca mulatta*, and to Orang-utans (*Pongo*) and Chimpanzees (*Pan*). All infants that survived breast feeding to the age of 12 to 16 weeks developed rickets.

With the present diet, *Macaca irus*, *M. mulatta*, *Cercocebus fuliginosus*, *Cercopithecus sabeus*, *C. grivet*, *C. mozambicus*, *Cebus fatuellus*, *Papio papio*, and *Pongo pygmaeus*, have bred about as frequently as may reasonably be expected. Except for an occasional death that could not be attributed to malnutrition, all offspring, except those of *P. papio*, the Guinea baboon, have developed normally. These baboons, of which there have been five, developed rickets, however. All of them were born in the autumn, as were many of the others, and had little exposure to sunlight. They recovered promptly with appropriate artificial feeding. Possibly the greater vitamin D requirement of the baboon will prove to be characteristic of the type and may be related to the rapid growth of the facial bones to form the typical dog-like features; for it is in this part of the body, rather than in the thorax and extremities, that abnormal bone formation first appears.

Also to be noted in Table I is the reduction in the number of males in proportion to females in the colony. Breeding possibly has been influenced by this change, but the death rate was not materially affected. Injury by cage mates has contributed little to mortality rate at any time, although occasional losses from this cause occurred throughout the period. The average yearly death rate of 12 per cent. from 1935 to 1940 is to be compared with that of 25 per cent. from 1930 to 1935.

This diet for subhuman primates is based to a considerable degree upon recognized requirements of man, especially as to vitamins and minerals. It is essentially a modification of the diets suggested for these animals by Corson-White (1931) and by Tinklepaugh (1931, 1933) but is less complex than either of these. In consideration of the known food habits of the species of subhuman primates available for study it seemed that their dietary needs might be met adequately by using a mixed ration composed of easily available foods for domesticated animals. This has given an economical and palatable mixture which, combined with accessory foods, seems to be a reasonably complete diet. An obvious fault possibly is the low fat content, but thus far there is no indication that this is an important lack.

Whatever criticisms may be offered to this system of feeding, it seemed reasonable to assume that the mixed ration with some of the supplements also would meet the requirements of many other species of mammals and

birds. In deciding upon the relative amounts of mixed food, vegetables and fruits for these animals, preferences as well as presumed needs, as indicated by experimental studies of diet, field studies of food habits and the structure of the intestinal tract, have served as guides.

Other Mammals. The mixed ration that has been described constitutes from 50 to 60 per cent. of the diet of rodents of the following genera: *Glaucomys*, *Sciurus*, *Citellus*, *Hystrix*, *Erethizon*, *Dasyprocta* and *Neotoma*. Supplementary foods are apples, carrots, sweet potatoes and green vegetables. This diet, the mixed ration and vegetables, also forms from 60 to 70 per cent. of the intake of the bears (Ursidae) and raccoons, coatis and kinkajous (Procyonidae). Horse-meat and fish supply the remainder of their intake. The present quarters for these animals do not favor breeding, but as judged by appearance, activity, growth of fur and postmortem examinations, the diet seems adequate for growth and maintenance.

Birds. A large number of species of so-called seed- and insect-eating birds, Passeriformes, many of the parrots, Psittaciformes, all Columbigiformes, Galliformes, and Anseriformes, are fed one diet, the chief element being the mixed ration that was developed for the apes and monkeys. This food makes up about 70 per cent. of their intake. Supplementing it are green vegetables, sprouted grains and fruits. In view of the known food habits of many species of Passeriformes, the mixed ration is probably too low in fat content to be completely satisfactory, and it has proved to be unsuited for unfeathered young of local species of this order. Further investigation is necessary to determine whether or not a special diet for the adults of this order is economically justified. During the present test period these birds have shown noteworthy improvement in plumage colors, and lessened morbidity and mortality.

Breeding as a measure of the adequacy of the diet must, however, be limited to birds of the families Phasianidae and Anatidae, for few others are exhibited under conditions favorable to this activity. Prior to 1935, about 70 per cent. of the intake of these two families consisted of a mixture of equal parts of cracked corn and wheat screenings, supplemented by green vegetables. Crushed limestone and oyster-shell were supplied *ad libitum* to the pheasants.

Phasianidae. The pheasants, junglefowl and larger varieties of quail are exhibited in pens that provide from 150 to 200 square feet of floor space. Small types of quail have less space while wild turkeys are exhibited in a much larger pen, and peafowl are at liberty on the grounds. Visitors may pass within a few feet of all enclosures. From two to seven pheasants of one species, with one adult male to the group, occupy each pen. Junglefowl, turkeys and quail are kept in small flocks in which there may be more than one male.

From 1930 to 1935, breeding in this group was limited chiefly to silver pheasants (*Gemnaeus nycthemerus*) but occasional young were produced also by Swinhoe's pheasant (*Gemnaeus swinhoii*), junglefowl (*Gallus gallus*), the common peafowl (*Pavo cristatus*) and stubble quail (*Coturnix coturnix*).

Since the present diet was offered, five species of pheasants have produced fertile eggs regularly, but none has had greater than 15 per cent. fertility. Compared to this is the fertility rate of more than 50 per cent. for wild turkeys and three species of quail. But in spite of the relatively unfavorable conditions under which these birds live, the number of young produced by this group from 1935 to 1940 was four times greater, in proportion to the breeding stock, than from 1930 to 1935, and the annual death rate fell from 38 to 24 per cent.

Anatidae. Many of the members of this family are exhibited in one body on an artificial pond. Others are kept in smaller enclosures along a

stream. The mute swan, (*Cygnus olor*), is the only species provided with a separate space where the pair may nest. In all locations visitors may approach within a short distance of the birds.

From 1930 to 1935, breeding was limited to Canada geese, (*Branta canadensis*) and mallard ducks, (*Anas platyrhynchos*), which hatched an average of twelve young per year. With the present diet these continue to breed and, in addition, mute swans, (*Cygnus olor*), and upland geese (*Choenphaga magellanica*) have produced young regularly, and blue geese (*Chen caerulescens*) and Egyptian geese (*Alopochen aegyptiacus*) have occasionally nested. From 1935 to 1940, an average of 43 young were hatched each year. Young birds of both the family Anatidae and Phasianidae are fed the mixed ration with about 10 per cent. of finely chopped green vegetables. Growth has been entirely satisfactory and loss negligible. This diet for Phasianidae and Anatidae corresponds in all essentials to that developed by Callenbach, Murphy & Hiller (1932) for ring-necked pheasants. More recent experimental studies of the nutritional requirements of chickens, pheasants, turkeys, ducks and geese, (Barnum, 1935), (Baird & Green, 1935), (Bethke, Record & Kennard, 1936), (Norris, Elmore, Ringrose & Bump, 1936), (Milby & Henderson, 1937), show that the food supplies all necessary elements in adequate quantities, especially those essential to high fertility and good "hatchability."

Breeding of both Phasianidae and Anatidae probably has been limited more by small enclosures, crowding by other species and by disturbances of visitors than by any other factors. Pheasants should have larger pens, and geese and swans probably should be separated in pairs for the best results.

HERBIVOROUS ANIMALS.

The composite ration used for herbivorous animals contains beet pulp, chopped vegetables and a portion of the following dry mixture:

Brewer's grains (Dry).....	400 lbs.
Yellow cornmeal.....	200 lbs.
Crushed oats.....	200 lbs.
Soybean oil meal.....	200 lbs.
Alfalfa meal (Dehyd.).....	100 lbs.
*Brewer's yeast (Dry).....	40 lbs.
Oyster-shell flour.....	40 lbs.
*Iodized salt.....	10 lbs.
*Codliver oil concentrate.....	5 lbs.

This mixture also is prepared in bulk for use as needed. The ration is made up in the late morning and fed in the early afternoon. The beet pulp is wet with an approximately equal weight of water and soaked for 1 to 2 hours. An amount of the dry mixture equal to the dry weight of the beet pulp, and chopped cabbage or carrots in an amount about equal to 10 per cent. of the total dry weight, are added and the whole well mixed. This forms from 60 to 70 per cent. of the diet of the herbivorous animals. The remainder is obtained from mixed timothy and clover hay. With different species of herbivorous animals the feeding allowances of the mixed ration vary between 10 and 40 grams per kilogram of body weight, or 1 to 4 pounds of the completed mixture per 100 pounds of body weight.

The approximate composition of the completed ration is:

Protein.....	15	per cent.
Digestible protein.....	11.5	" "
Total digestible nutrients.....	70	" "
Calcium.....	1.16	" "
Phosphorus.....	0.25	" "

* See formula for omnivorous animals.

This mixture is a modification of rations that have been developed for cattle and sheep (Morrison, 1939). In view of the type of hay available, the protein content is lower than that usually recommended. But the problem here is simply one of maintaining breeding stock in good condition. Neither milk production nor rapid gains in weight are considerations. Beet pulp is used as palatable diluent because concentrates are not tolerated well by deer in captivity. Vegetables are included also for palatability. The cost of the mixture compares favorably with others that provide equal amounts of digestible nutrients with smaller numbers of constituents.

Artiodactyla. The majority of herbivorous animals that have been available for study are included in the families Cervidae, Bovidae and Camelidae of the order Artiodactyla. Some species of cervines and bovines always have bred in the garden. Hence consideration will be given mainly to these groups.

All of the deer, Cervidae, except delicate tropical species such as the barking deer, *Muntiacus muntjak*, all of the Camelidae and the hardier Bovidae, are kept in open paddocks throughout the year. These are provided with tight shelters. African antelopes, Bovidae, live in heated quarters during the cold weather, but have access to outdoor enclosures during the warmer months. Natural pasturage is scanty or absent in all pens.

Prior to 1935, approximately half the diet of these ruminants was made up of mixed grains (equal parts by volume of cracked corn, crushed oats and wheat bran) and the remainder of mixed timothy and clover hay. Rock salt was the only mineral supplement. African antelopes received small amounts of fresh vegetables twice weekly.

TABLE II.

Records of Births and Deaths for Three Families of Artiodactyla (Bovidae, Cervidae and Camelidae) at the Philadelphia Zoological Garden During Each of Five Years Before and Five Years After the Diet Was Changed.

Year	Stock		Acquisitions	Births	Deaths	Sales
	♂	♀				
1930	70	48	1	20	14	6
1931	77	42	3	19	15	4
1932	74	48	2	17	24	2
1933	67	48	0	21	12	8
1934	59	57	15	16	24	10
1935	60	53	6	20	28	14
1936	53	44	12	14	18	9
1937	53	43	15	16	10	16
1938	54	47	0	18	13	24
1939	41	41	6	20	7	10

Neither the birth rate nor the death rate of these animals has changed materially since the present diet was offered. From 1930 to 1935, the average annual birth rate was 1 for 2.6 females and from 1935 to 1940, 1 for 2.3 females. The average annual death rate was approximately 15 per cent. throughout the period, but would have fallen to 12 per cent. after the change of diet, except for the sacrifice of 16 animals as excess or as unfit specimens.

From these observations it appears that the present diet offers little advantage, but the response of the ruminants is not well expressed by these data. Certain species of Cervidae and Bovidae seemed to be able to live and reproduce fairly well on the former diet. Examples of these are the Barbary sheep, *Ammotragus lervia*, Sika deer, *Sika nippon*, and possibly the Central American deer, *Odocoileus virginianus nemoralis*. On the other hand, American bison, *Bison bison*, elk, *Alces alces*, fallow deer, *Dama dama*, red deer, *Cervus elaphus*, Axis deer, *Axis axis*, and white-tailed deer, *Odocoileus*

leucurus, also reproduced but young matured slowly, rarely attaining the stature of wild-bred specimens. Many offspring of all species died shortly after birth, either because of lack of vigor or failure of the mother to lactate; and adult elk and white-tailed deer commonly developed progressive paralysis of the posterior extremities, due possibly to vitamin A deficiency.

The present diet seems adequate for maintenance of all species of Artiodactyla with which it has been tested. White-tailed deer have not developed paralysis of the posterior extremities during the five-year test period. Elk were not available for part of the time. Occasionally, newborn young, especially of hog deer, *Hyelaphus porcinus*, are lost shortly after birth, but in general, offspring mature normally. As one example, two generations of barking deer, *Muntiacus muntjak*, have bred while confined entirely within doors.

More recent studies of the nutritional requirements of domesticated ruminants, (Thurston, Eckles & Palmer, 1926), (Bechdel and co-workers, 1928), (McElroy & Gross, 1939), (Winegar, Pearson & Schmidt, 1940), indicate that the present diet for wild ruminants may be unnecessarily complex. Possibly it is, but the use of such a mixed ration seemed to be justified by the conditions under which the animals are exhibited, and by the fact that it is fed to non-ruminant herbivores such as the elephant, rhinoceros, hippopotamus, tapir, kangaroo and hyrax.

CARNIVOROUS ANIMALS.

Mammals and birds of this dietary group receive a ration which contains raw, ground horse-meat (approximately 20 per cent. glandular organs) 60 per cent., ground green vegetables, 10 per cent., and 30 per cent. of the following mixture:

Soybean oil meal.....	30 per cent.
Peanut oil meal.....	25 " "
Buttermilk (Dry)	25 " "
Oyster-shell flour	6 " "
Alfalfa leaf meal (Dehyd.).....	4 " "
*Brewer's yeast (Dry).....	4 " "
*Cod-liver oil concentrate.....	4 " "
*Iodized salt	2 " "

This is fed to animals of the families Canidae, Mustellidae, Viverridae, and Didelphiidae, and to birds of the orders Strigiformes and Accipitriformes. For these animals daily feeding allowances are 75 to 100 grams per kilogram of body weight, or 1 to 4 ounces per pound. It also forms part of the diet of other mammals and birds, but it has not been a successful diet for adult wild Felidae. On this diet, "husky dogs," foxes, wolves, skunks and opossums have bred successfully and offspring have matured without obvious defects. Judged by breeding, development of young and growth of fur, the ration seems to be adequate for these animals.

The hawks and owls, Accipitriformes and Strigiformes, have not had opportunity for breeding but the drop in mortality rate has been so pronounced as to warrant mention. From 1930 to 1935, the stock of Accipitriformes averaged 39.6 birds each year of which about 30 per cent. died. With almost the same average stock, 40.8 birds, from 1935 to 1940, the annual death rate has dropped to less than 10 per cent. The average number of Strigiformes exhibited from 1930 to 1935 was 19.8 birds of which 59 per cent. died each year. From 1935 to 1940 an average stock of 32.2 birds also lost less than 10 per cent. Prior to 1935 these birds had been fed only horse-meat. The chief causes of death were either non-specific inflammatory disease of the intestinal tract or simply failure of appetite. These conditions are no longer factors in mortality.

* See diet for omnivorous animals.

This diet for carnivores is one of many combinations that have been tested. Early in the work, 30 per cent. of the dry mixture for omnivores was used instead of the present dry material with the result that much of the grain-meals were undigested and stools were soft. This is in keeping with the observations of Hodson & Maynard (1938) on mink. In its essentials the present diet corresponds to the suggestions of Kellogg (1939).

On the whole this work has been an attempt to adapt available standards of nutrition to the needs of a zoological garden. The aim has been to provide acceptable, adequate and economical diets. Little training is necessary to induce the animals to take the foods, and costs of feeding have been reduced approximately 20 per cent. Whether or not the diets are completely adequate, in that continued breeding in captivity will be possible, remains to be determined. In all probability, the mixed rations that are being used could be further simplified without loss. The inclusion of iodized salt in all mixtures may be questioned, but its need seemed indicated by the frequent occurrence of hyperplasia of the thyroid in both mammals and birds that were examined prior to 1935.

It must be emphasized that a five-year test period is a relatively short time in which to evaluate reactions to these diets. This interval is only part of the normal life-span of all except the more short-lived specimens. The responses of the second and third generations must be awaited.

In planning the formulae efforts were directed to simplifying mixtures, using easily weighed amounts or standard bulk quantities as much as possible. Also, in actual practice food allowances are not arranged on a grams per kilogram of body weight per day basis. Instead, easily understood measures of the prepared foods are employed so that neither the keepers nor the workmen who prepare the foods are compelled to do more than follow a simple routine.

SUMMARY.

A rather elastic classification of mammals and birds according to known food habits and the general structure of their alimentary tracts, permits the subdivision of the greater number of species that are exhibited in zoological gardens into three general groups. Three diets, the make-up of which was determined by the known requirements of related species, whether man or domesticated animal, by the preferences of the wild specimens, and by practical considerations, have been used for five years. Response to these diets, as judged by death rates, birth rates and development of young, indicate that advances in human and animal nutrition may be successfully applied to the feeding problems of zoological gardens.

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